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(54) Key-operable locks

(57) The lock includes a cylinder 11 rotatably mounted in a body 10. The cylinder has a keyway for accepting a conventional edge profile key, but instead of the usual pin/tumbler arrangement, there is an edge profile follower 17 which is displaceable by the edge of the key as the key in inserted and which coacts with the movable input element 16 of an inductive transducer 15 connected in on a.c. circuit. This supplies signals to a recognition circuit which, if an acceptable edge profile is detected, energises a solenoid 12 to withdraw a detent element 14 which normally prevents turning of the cylinder 11. The transducer of Fig. 2 is a linear variable inductive transducer and also as shown in Fig. 2, the a.c. circuit includes on oscillator 20 which supplies an a.c. signal to primary winding 21 of the transducer, the position of the input element 16 determining the amplitude of output signals from secondary windings 22 of the transducer which are connected to a detector circuit 23 to provide a d.c. output. Such is supplied to analog-to-digital converter 24 which is connected to a microprocessor 25 which is

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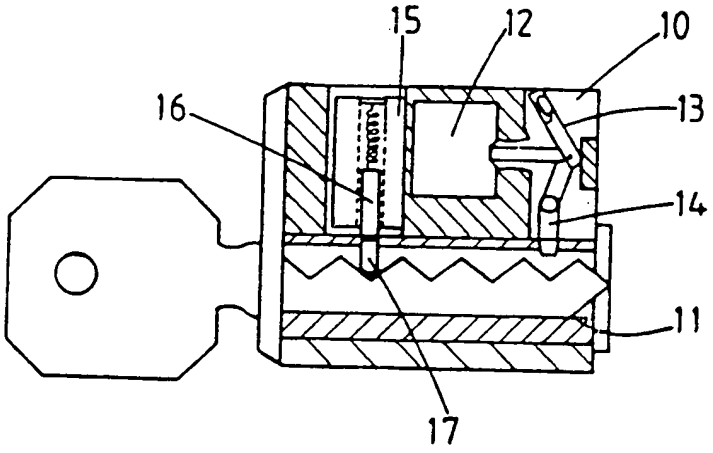

FIG.1.

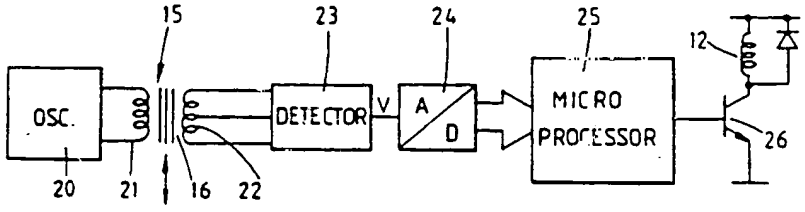

FIG.2.

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programmed to act as the recognition circuit and having data stored in its memory e.g. regarding keys/times. In the circuit of Fig. 3 the transducer (115) is on inductor forming part of frequency determining network of an oscillator (117) the output of which is applied to a frequency to voltage convector (118).

Solenoid 12 operates on detent 14 via overcentre linkage 13.

SPECIFICATION

Key-operable locks

This invention relates to key-operable locks which are operable by keys of the type used for operating pin-tumbler cylinder locks, i.e. keys having a shaped edge profile which co-operates with the pin tumblers in a cylinder to align such tumblers with the cylinder/bearing interface to permit turning of the cylinder by the key.

Such keys are in very widespread use and various systems for multi-level master keying operation have been adopted. Modern master key requirements are becoming increasingly complex which place increasing exacting requirements on key and lock design. There is a requirement for special locks which can be operated by certain keys within a master key system, but which can be changed readily if necessary. It is also desirable to provide some means for recording the use of a particular key.

The above requirement, can it is believed, be met by the use, in certain high security or limited access locations, of a lock in which the key is read electronically and the lock is released by electrical means. It is required, however, that the key should still be capable of operating conventional locks and that the lock should be interchangeable with a conventional lock. The interchangeability requirement gives rise to a very considerable problem of size and it is an object of the invention to provide a lock in which the key is read electronically in a compact form capable of fitting the spaced occupied by a conventional pin-tumbler cylinder lock.

In accordance with the invention there is provided a lock comprising a body having a bore, a cylinder rotatably mounted in said bore, a keyway in said cylinder for receiving a key having a shaped edge profile, a key edge profile follower movably mounted in a transverse bore in the cylinder, an inductive position transducer mounted in the body and coacting with the profile follower so that a movable input element of said transducer is displaced by said profile follower as a key is inserted into the keyway, an a.c. circuit in which said inductive transducer is connected so as to produce an output corresponding to the position of said profile follower, a recognition circuit for comparing the output of said a.c. circuit with stored data, detent means acting between the body and the cylinder to present turning of the cylinder and means energisable by said recognition circuit on recognition of a key edge profile corresponding to the stored data to render said detent means inoperative so as thereby to permit turning of said cylinder.

The inductive transducer referred to above may be a transformer in which the movable input member operates to vary the coupling between a primary winding to which an a.c. signal is applied and a secondary winding. In this case the a.c. circuit referred to above includes means sensitive to the amplitude of the secondary winding output. A linear variable differential transformer is preferred.

Alternatively the inductive transducer is an inductor with a core movable by the movable input member to vary the inductance of the inductor. In this case the inductor may be one element of an oscillator, the frequency of which is dependent on the position of the movable core.

In the accompanying drawings:—

Figure 1 is a diagrammatic cross-sectional view of one example of a lock in accordance with the invention;

Figure 2 is a block diagram of an electrical circuit used in the example shown in Fig. 1; and

Figure 3 is a block diagram of another electrical circuit in which could alternatively be used.

Referring firstly to Fig. 1 the lock shown includes a body 10 of non-ferrous metal in a bore in which a cylinder 11 of non-ferrous metal is rotatably mounted. The body 10 is conventionally shaped and dimensioned to fit within the space normally occupied by a conventional cylinder lock and the cylinder is adapted to be mechanically coupled, as is conventional, to a door fastening means.

Instead of the usual pin-tumbler arrangement for locking the cylinder 11 to the body 10, however, there is provided a solenoid 12 mounted in the body and operating on an overcentre linkage 13 which drives a detent element 14 slidable in a cross bore in the body 10 into a suitably positioned socket in the cylinder 11. The solenoid 12, when energised, withdraws the detent element thereby freeing the cylinder 11 to turn in the bore in the body for releasing the door fastening means.

Also mounted in the body 10 is an inductive transducer 15 which incorporates a movable input element 16 in the form of a core of ferrous material. The transducer is preferably in the form of a linear variable differential transformer. The movable input element 16 coacts with a key edge profile follower 17 which is slidably mounted in a cross bore in the cylinder 10. The follower 17 projects into a keyway in the cylinder 10 so as to be displaceable by the edge of a key as it is inserted into the keyway.

Fig. 2 shows an electrical circuit which is used in conjunction with the lock of Fig. 1. This circuit is preferably located within the casing or furniture of the door fastening means with which the lock is used. As shown in Fig. 2, the circuit includes an oscillator 20 which supplies an a.c. signal to a primary winding 21 of the transducer. The position of

the input element 16 determines the amplitude of output signals from the secondary winding 22 of the transducer, which secondary windings are connected to a conventional detector circuit 23 which provides a d.c. output of magnitude dependent on the position of the element 16. This d.c. output is applied to an analog-to-digital converter 24 connected to a micro-processor which is programmed to act as a recognition circuit which compares the sequence of signals it receives from the converter 24, as a key is inserted, with data stored in its memory and provides an output to a semiconductor switch element 26 so as to energise the solenoid 12 when this signal sequence matches the stored data.

The micro-processor memory may contain data corresponding to a large number of different keys and the micro-processor may be programmed to render certain of these valid or invalid according to the time of day and/or day of the week. It may also store data corresponding the time when each key is used for subsequent collection by an appropriate data collection unit.

The overcentre linkage 13 is provided to ensure that the lock cannot be released by inserting a probe into the keyway since it prevents the detent element being moved except by the solenoid.

If desired the cylinder may incorporate a single conventional pin-tumbler arrangement at a position adjacent the entry to the keyway This would be operated by a part of the edge profile of the key which is not "read" by the electronics and would preferably be so arranged that the pin-tumbler does not reach its unlocked position until after "reading" of the key profile has been completed an the solenoid has been energised. This arrangement is designed to ensure that torque applied to the key is accepted by this pin-tumbler arrangement until the detent element is withdrawn so that no frictional load can be placed on the detent element resisting its withdrawal

Turning now to Fig. 2, the transducer 115 in that case comprises an inductor, the inductance of which varies in accordance with the position of the core 116. This indicator 115 forms part of the frequency determining network of an oscillator 117 the output of which is applied to the input of a frequency-to-voltage converter 118 (incorporating, for example, a phase locked loop circuit) The output of converter 118 is applied to the analog-to-digital converter 24 operating as in Fig. 2.

In both examples actual loading of the memory with data relating to key edge profile may be effected utilizing the signals actually produced when the key in question is inserted

CLAIMS

1. A lock comprising a body having a bore, a cylinder rotatably mounted in said bore, a keyway in said cylinder for receiving a key having a shaped edge profile, a key edge profile follower movably mounted in a transverse bore in the cylinder, an inductive position transducer mounted in the body and coacting with the profile follower so that a movable input element of said transducer is displaced by said profile follower as a key is inserted into the keyway, an a.c. circuit in which said inductive transducer is connected so as to produce an output corresponding to the position of said profile follower, a recognition circuit for comparing the output of said a.c. circuit with stored data, detent means acting between the body and the cylinder to prevent turning of the cylinder and means energisable by said recognition circuit on recognition of a key edge profile corresponding to the stored data to render said detent means inoperative so as thereby to permit turning of said cylinder.

2. A lock as claimed in claim 1 in which said inductive transducer is a transformer, said movable input member operating to vary the magnetic coupling between a primary winding to which an a.c. signal is applied and a secondary winding.

3. A lock as claimed in claim 2 in which said a.c. circuit includes means sensitive to the amplitude of the output of the secondary winding.

4. A lock as claimed in claim 2 in which said transformer is a linear variable differential transformer.

5. A lock as claimed in claim 1 in which said inductive transducer is an inductor having a core movable by the movable input member so as to vary the inductance of the inductor.

6. A lock as claimed in claim 5 in which said inductor forms one element of an oscillator, the frequency of which is dependent on the position of the movable core.

7. A lock as claimed in claim 5 in which said a.c. circuit also includes a frequency to voltage converter, the output of said converter representing the position of said profile follower

8. A lock as claimed in any preceding claim in which said recognition means includes a converter circuit for converting the output of said a.c. circuit to a stream of digital data, and a microprocessor containing stored digital data representing the edge profile of at least one acceptable key and programmed to compare the data stream from said converter with said stored digital data.

9. A lock as claimed in any preceding claim in which said detent means comprises a detent element slidable in a radial direction relative to said bore between a locking position in which it enters a socket in the cylinder so as to block turning of the cylinder, and a withdrawn position, and transmission means connecting said energisable means to said detent element for displacing the latter between

said positions.

10. A lock as claimed in claim 9 in which said transmission means comprises a linkage.

11. A lock as claimed in claim 10 in which said linkage is an overcentre linkage arranged to be driven overcentre by said energisable means.

12. A lock substantially as hereinbefore described with reference to the accompanying drawings.

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